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Laser-Based Science at the Center for Nanoscale Materials

Presented by:

David Gosztola

Nanophotonics Group

Center for Nanoscale Materials

Argonne National Laboratory

Research Programs at CNM

■ Theory & Modeling

- Self-assembly processes
- Nanocatalytic activity of small clusters
- Multiscale theory of photon confinement and propagation
- Device modeling “Virtual Fab Lab”
- Charge transfer processes in bio-inorganic composites

■ X-ray Microscopy

- Hard X-ray nanoprobe (Sector 26)
- Large numerical aperture optics for hard X-rays
- *In situ* studies of nanomaterials growth processes

■ Electronic & Magnetic Materials & Devices

- Nanoferroelectric materials and devices
- Spin-based and related quantum computing materials

■ Nanofabrication



- Electron beam (e-beam) lithography
- Optical lithography
- Focused ion beam patterning

■ Nanobio Interfaces



- Chemical catalysis
- Sensors
- Environmental remediation

■ Nanophotonics



- Materials generation via synthesis and lithography
- Optical instrumentation development for advanced characterization

Laser-Based Tools: Nanofabrication Group

■ Particle Image Velocimetry Microscope

- Dual-beam, pulsed, doubled Nd:YAG (532 nm)
- Micron resolution velocity measurements
- Microfluidics and magneto-hydro-dynamic flow applications
- Class I instrument containing a Class IV laser

■ Interferometer-based holographic lithography

- Currently under construction in clean room
- 325 nm HeCd laser interferometer

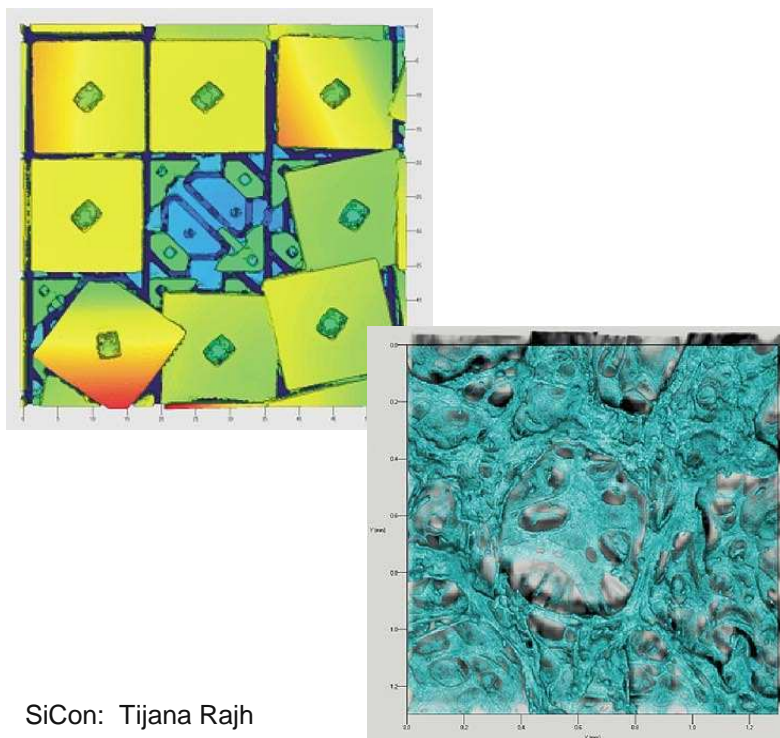


SiCon: Derrick Mancini

Laser-Based Tools: Nanobio Group

■ Zeiss LSM-510 Laser Scanning Confocal Microscope

- Used for 2D and 3D spatial mapping of biological and inorganic fluorescent samples
- 458, 477, 488, 514, 561, 632 nm CW lasers
- 800 nm modelocked Ti:Sapphire laser for two-photon excitation
- 32-channel spectrometer for multi-component spectral deconvolution



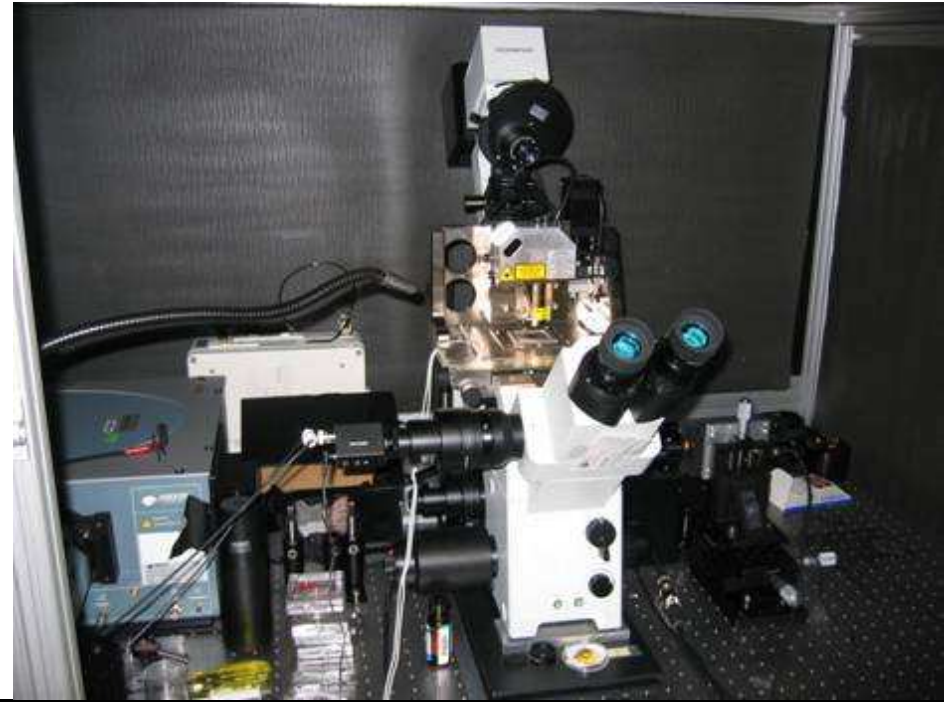
SiCon: Tijana Rajh

Laser-Based Tools: Nanophotonics Group

- Near-field scanning optical microscope
- Confocal Raman Microscope
- Ultrafast transient absorption system
- Ultrafast for ultrasmall facility

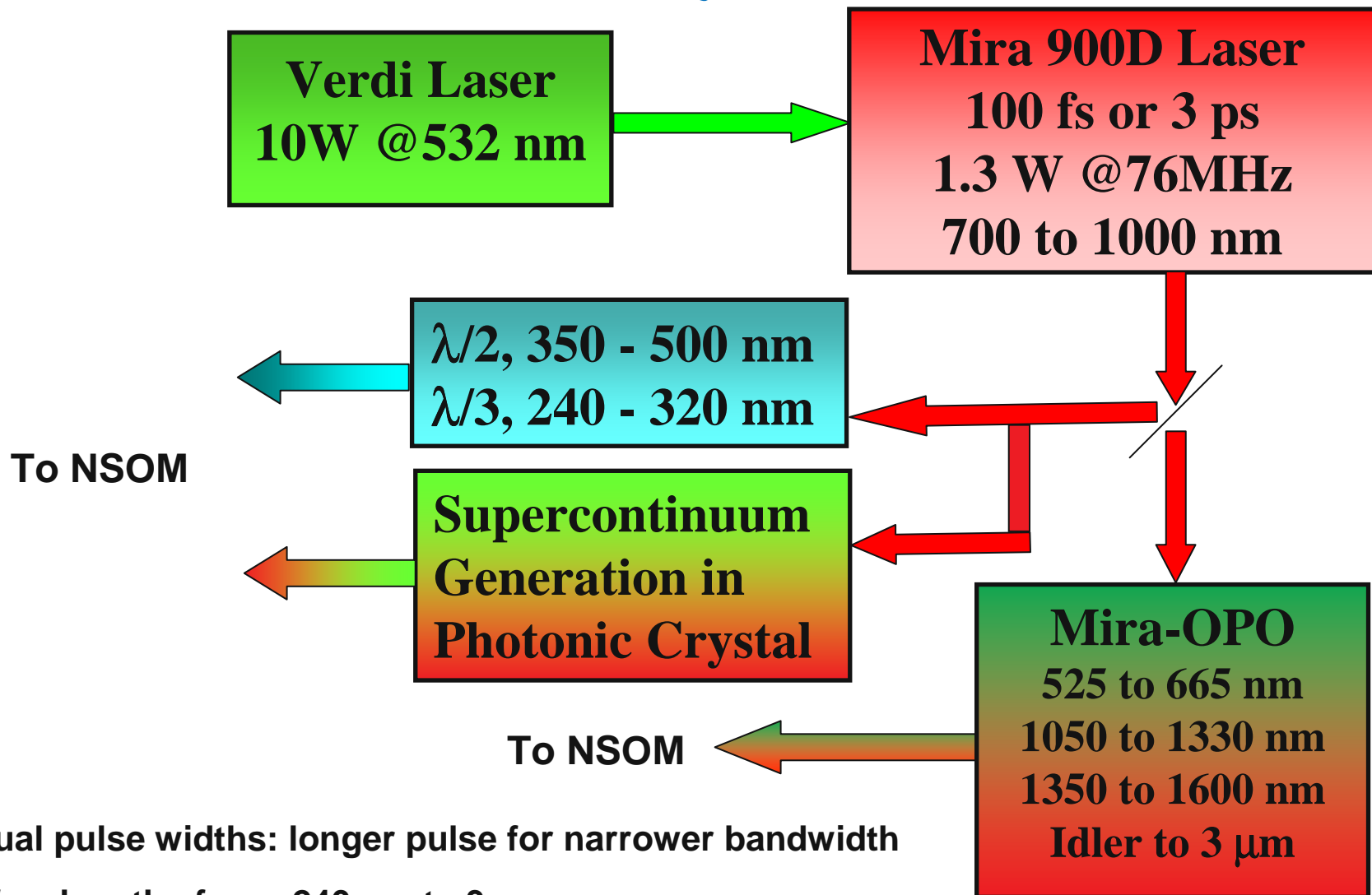
Nearfield Optical Scanning Microscope (NSOM)

- Sub-diffraction-limited optical resolution
- Class IV laser system
 - 250nm – 3000 nm
 - CW, 3 ps, 120 fs, <1 mW to >8 W
- Confocal fluorescence mapping and spectra
- Atomic force microscopy
- Fluorescence life-time measurements
~30ps with TCPC



SiCon: Gary Wiederrecht

Ultrafast Laser System for NSOM

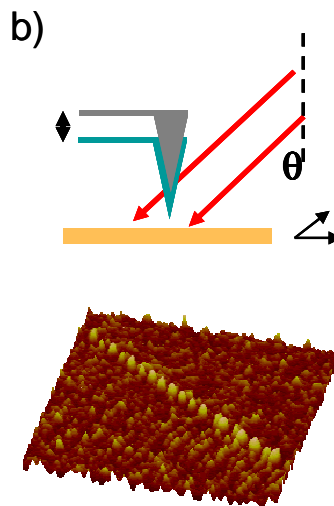
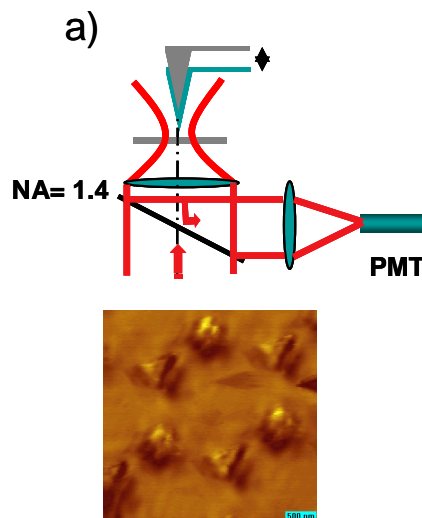


- Dual pulse widths: longer pulse for narrower bandwidth
- Wavelengths from 240 nm to 3 μm
- High repetition rate

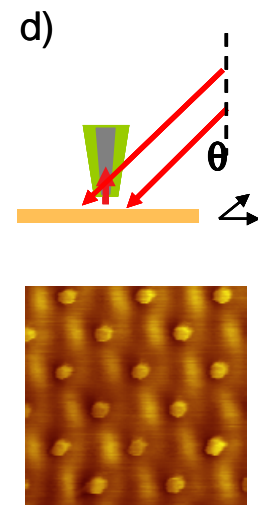
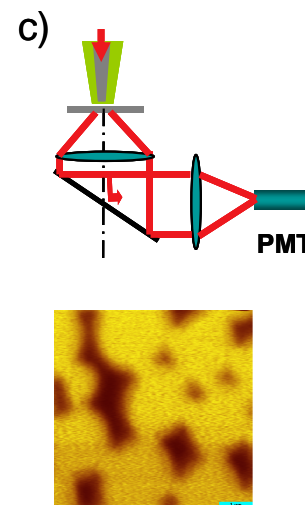
Near-field Optical Scanning Microscope (NSOM)

- Sub diffraction limited optical resolution ≈ 100 nm
- Based on scanning probe microscopy
- Highly reconfigurable

Apertureless NSOM
Uses standard AFM tips

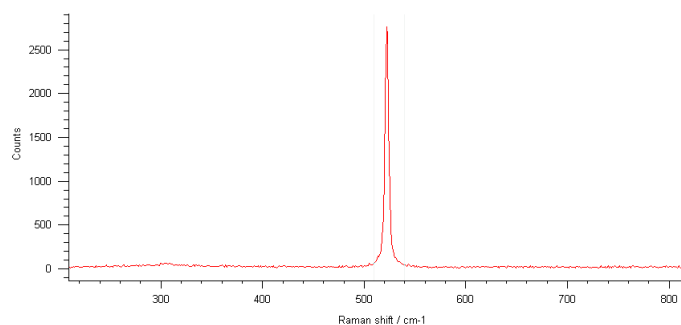
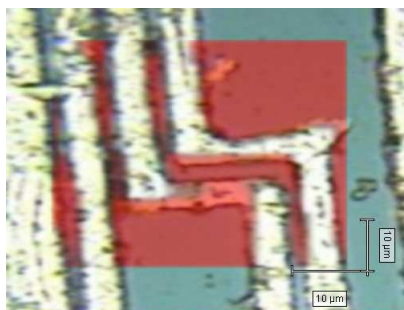


Apertured NSOM
Uses pulled fiber optic probe



Confocal Laser Raman Microscope

- Confocal Raman microscope can be used for both identification and structural analysis
- Micron resolution allows spectra from discrete nanoparticles, as well as from the bulk
- Automated X,Y,Z-axis mapping capability for large area mapping
- Multiple laser excitation wavelengths - 633, 514, 442, 325 nm



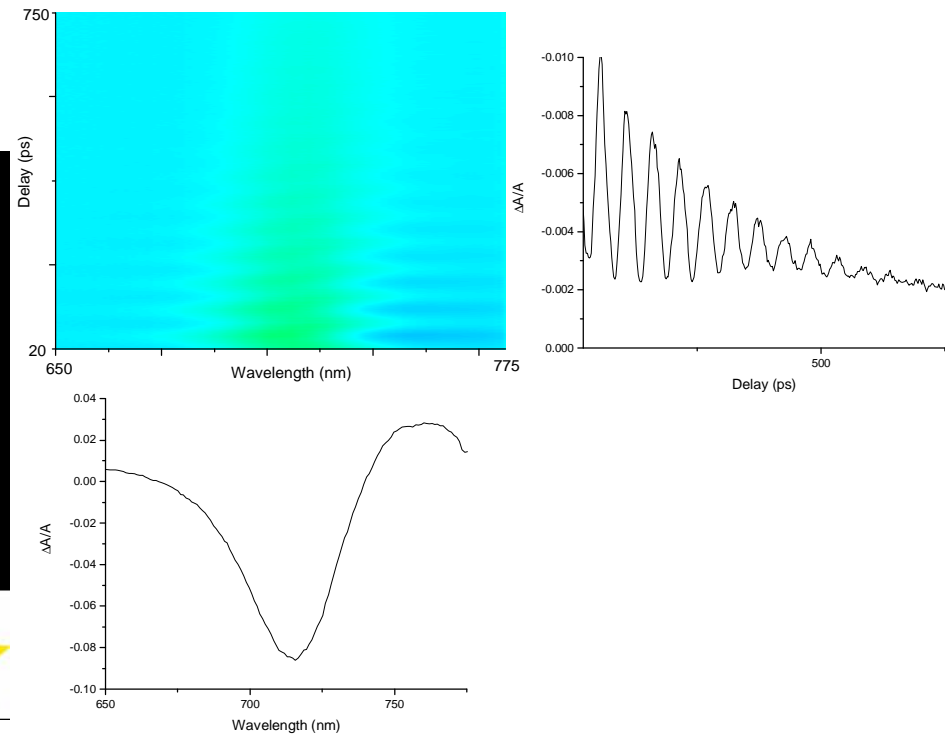
SiCon: David Gosztola



Ultrafast Transient Absorption Spectrometer

- Based on SP Spitfire-Pro 5 kHz regen pumping Topas OPA
 - 250 nm – 10 μm excitation
 - 450 nm – 1.2 μm probe
- 100 fs time resolution
- Full spectral readout at 5 kHz

60 nm gold nano bi-pyramids



Data courtesy of M. Pelton

SiCon: David Gosztola

Ultrafast for Ultra Small Facility

- **Currently under construction**
- **Micra Ti:Sapphire – compressible to 15 fs at the sample**
- **Pulse shaping and pulse picking to control spectrum, phase, and repetition rate**
 - **Transient pump-probe**
 - **TCPC fluorescence lifetime measurements**
 - **100 mm sample stage travel with 10 nm repeatability**

CNM: Becoming a user

- Similar to APS beamline requests
- Submit user proposals at <http://nano.anl.gov>
 - Internal feasibility review, external scientific merit review
 - Rapid access can be granted for proof-of-concept experiments
- May also enter into collaborative research with CNM Staff
 - 50/50 internal/user research
 - Cross-program collaborations encouraged